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(FROM THE RESEARCH LABORATORIES OF THE DRY MILK COMPANY, NEW YORK)

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THE ANTIRACHITIC AND CALCIFYING PROPERTIES OF SUMMER- AND WINTER-PRODUCED DRY MILK, IRRADIATED AND NON-IRRADIATED.

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It has been known for some time that the frequency and intensity of infantile rickets is somewhat dependent upon the season of the year. According to the observations of Hess (1) and of Lasch and Miemetz (2) the spontaneous healing of rickets seems to be coincident with the increase in duration and intensity of sunshine. Hess noted that this relationship was manifested in May, whereas, Lasch and Miemetz, working in Breslau, Germany, observed its occurrence in June. In view of the abundance of data now available regarding the efficacy of ultra-violet light therapy for the treatment of rickets, these clinical observations serve primarily as confirmatory statistical evidence.

The inherent variations in the quality of the milk used in the infant dietary seem to have been given but scant consideration as a possible accessory factor contributing to the cause of the seasonal variation of rickets. In 1921, Hess and Unger (3) reported that milk from pasture-fed cows (summer-produced milk) failed to prevent the development or to decrease the severity of rickets when fed during the winter. Dry milk was used for their experiments and even though it must have been stored for several months, the investigations of Hess and Weinstock (4) and of Hart, Steenbock, and Lepkovsky (5) indicate that there would be little or no deterioration of the antirachitic factor during storage for that length of time. The failure of summer-produced milk to prevent rickets in winter is not unexpected as it is generally known that milk does not contain sufficient amount of the antirachitic factor to warrant dependence on it as a curative or prophylactic agent. The inadequacy of summer-produced milk does not, how-

ever, indicate that winter-produced milk may not be even more inferior, antirachitically considered.

In view of the benefits known to accrue as a result of direct body exposure to ultra-violet light of the sun's rays, or from artificial sources, it would seem that the milk of lactating animals might conceivably vary in antirachitic potency with variations in the degree of ultra-violet light to which the animal was exposed. Luce (6) has suggested such a relationship but particularly emphasizes the diet of the cow as an important cause of variations in the antirachitic factor. Steenbock *et al.* (7) have already shown that the antirachitic properties of goat milk can be increased by exposing the animal to the rays of the quartz mercury vapor lamp. Falkenheim, Völtz, and Kirsch (8) have likewise shown that irradiation of the cow increases the antirachitic properties of the milk. These findings have a direct bearing on the question of fluctuations in the antirachitic potency of winter-produced and summer-produced milk from the northern latitudes.

Daniels, Pyle, and Brooks (9) observed that the young rats of milk-fed mothers born during February and March of 1926 were smaller, and that their rate of growth was less rapid than those born and reared under similar conditions during other months of the year. They attribute this condition to the relatively small amount of direct sunlight during the particular period in question and to substantiate this conclusion they cite the fact that pronounced improvement was noticed when irradiated milk was fed. Since numerous investigators (7, 10–16) have shown that the antirachitic properties of milk are increased by exposure to ultra-violet light, the marked difference in rate of growth of young rats as noted by Daniels, Pyle, and Brooks, when receiving irradiated and non-irradiated winter-produced milk, readily permits the inference that winter milk may be lower in antirachitic potency than summer milk, and that irradiation of the winter product provides a means of overcoming this inferiority.

EXPERIMENTAL.

Inasmuch as the antirachitic activation of milk by ultra-violet light is about to become industrialized in certain branches of the milk business, studies have been undertaken for the purpose of determining the relative antirachitic potency of milk representa-

tive of the production during typical summer and winter months; and also for the purpose of determining the effect of irradiation on such milk. For these comparative studies, dry milk,[1] desiccated by the Just double cylinder process and containing 12 per cent butter fat, was used. A quantity of the product representing winter production was obtained in March and a similar quantity was again obtained in July. Both lots of the dry milk were packed in inert gas, hermetically sealed, and stored until the following November at which time the feeding tests were started. While it has been determined that both liquid and dry milk can be effectively activated by ultra-violet light, the use of dry milk for these comparative tests was obviously more desirable. By using the desiccated product it was possible to determine the antirachitic and calcifying properties of the winter- and summer-produced milk, activated and unactivated under identical conditions and in the winter season when environmental conditions were better suited for such tests.

Portions of each of the two lots of dry milk were irradiated in thin layers of uniform thickness at a distance of 26 inches from the lamp and for the same brief period of time. A Hanovia type quartz mercury vapor lamp was used as the source of light. White rats reared under our ordinary laboratory conditions were used as the test animals. At the age of 28 to 30 days they were started on the experimental feed which consisted of the Sherman and Pappenheimer ration, No. 84, supplemented by varying quantities of the reconstituted dry milk. The animals were kept in individual cages. At the end of 48 days they were killed and autopsied; the knee-joints from two animals of each group were subsequently radiographed.[2] The humeri were dried, crushed, extracted, and ashed according to the method of Bethke, Steenbock, and Nelson (17) except that the extraction period was extended to 8 days to insure removal of all fat.

Table I shows the average results obtained from each group of experimental animals receiving the different milks. The feeding of graded amounts, varying between 1 and 15 cc., of non-irradiated summer-produced milk resulted in a progressive increase in ash

[1] The dry milk used was Dryco brand.

[2] The radiographs were prepared and interpreted by Dr. Charles Gottlieb and Dr. A. F. Hess, of New York City.

TABLE I.

Comparative Antirachitic and Calcifying Properties of Summer- and Winter-Produced Milk, Irradiated and Non-Irradiated.

Milk fed daily with Ration 84.		Final weight.	Average weekly food consumption.	Average ash in humeri.	Rickets according to radiographs.	Rickets according to costochondral junctions.
Kind.	Amount.					
	cc.	*gm.*	*gm.*	*per cent*		
None		42	46.0	39.25	Marked.	Much enlarged.
Summer, non-irradiated	1	70	46.9	43.51	"	" "
" irradiated	1	61	44.1	48.38	Moderate.	Enlarged.
" non-irradiated	4	90	52.2	48.93	Slight.	Slightly enlarged.
" irradiated	4	87	56.5	55.46	Negative.	Normal.
Winter, non-irradiated	4	87	52.9	46.43	Moderate.	Enlarged.
" irradiated	4	92	56.2	52.38	Slight.	Slightly enlarged.
Summer, non-irradiated	9	121	59.3	55.52	"	" "
" irradiated	9	120	62.1	57.81	Negative.	Normal.
Winter, non-irradiated	9	114	55.2	50.95	Slight.	Slightly enlarged.
" irradiated	9	120	63.4	58.27	Negative.	Normal.
Summer, non-irradiated	15	135	57.2	60.22	"	"
" irradiated	15	138	61.4	60.83	"	"
Winter, non-irradiated	15	145	59.1	56.08	"	"
" irradiated	15	129	61.6	60.62	"	"

content up to 60.22 per cent. Similar amounts of non-irradiated winter-produced milk likewise caused a progressive increase in ash content of the bones, but the percentage in all cases was from 2 to 5 per cent lower than was obtained with the summer milk. The same quantities of the irradiated summer-produced milk gave results from 2 to 5 per cent higher than the same milk non-irradiated up to the 9 cc. quantity. At the 15 cc. level less than 1 per cent difference was found. In comparing the results from the irradiated and non-irradiated winter-produced milk it will be found that the irradiated product increased the ash content of the bones from $4\frac{1}{2}$ to 6 per cent more than the non-irradiated product even up to the 15 cc. level. The irradiated winter milk in all instances gave higher results than the non-irradiated summer milk; at the higher levels the irradiated winter milk gave substantially the same results as the irradiated summer milk.

The relationships shown by these data indicate a measurable difference in antirachitic and calcifying properties between summer- and winter-produced milk, but even though the winter product has less of the antirachitic factor than the summer product, its potency can be increased to a degree greater than that of the natural summer product by a brief period of irradiation with ultra-violet light. The data also indicate that under the conditions imposed by these experimental methods, the utilizable increment of antirachitic potency imparted to winter-produced milk by irradiation is greater than the utilizable increment imparted to the summer product. These results, taken as a whole, appear to confirm the existence of a significant interdependence between antirachitic properties and the degree of ultra-violet light to which the product itself, or its synthesizing agent, the body of the cow, has been exposed.

SUMMARY.

Summer-produced and winter-produced dry milk made by the Just double cylinder process tested for antirachitic and calcifying properties under identical conditions showed that the summer-produced milk possessed greater antirachitic and calcifying properties than the winter-produced milk.

Irradiation of the summer- and winter-produced dry milk imparted measurably greater antirachitic and calcifying properties

to both products. A greater increment of increase in calcifying properties was imparted to the winter-produced milk than there was to the summer-produced milk.

The results indicate that both winter- and summer-produced milk may have the same potential capacity for endowment with antirachitic and calcifying properties by ultra-violet light. The realization of this potential capacity is not attained in milk produced either in the summer or winter months. However, when the cows are subjected to the greater degree of solar irradiation prevailing in the summer months the embodiment of antirachitic and calcifying properties in the milk is greater than in the winter months when the animals are exposed to the activating rays to a much less degree. Because of the inherent conditions in the quality of the food consumed by cows in the temperate zones during the winter and summer months, the effect of such conditions on the antirachitic properties of the milk is not precluded by the data recorded herein.

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